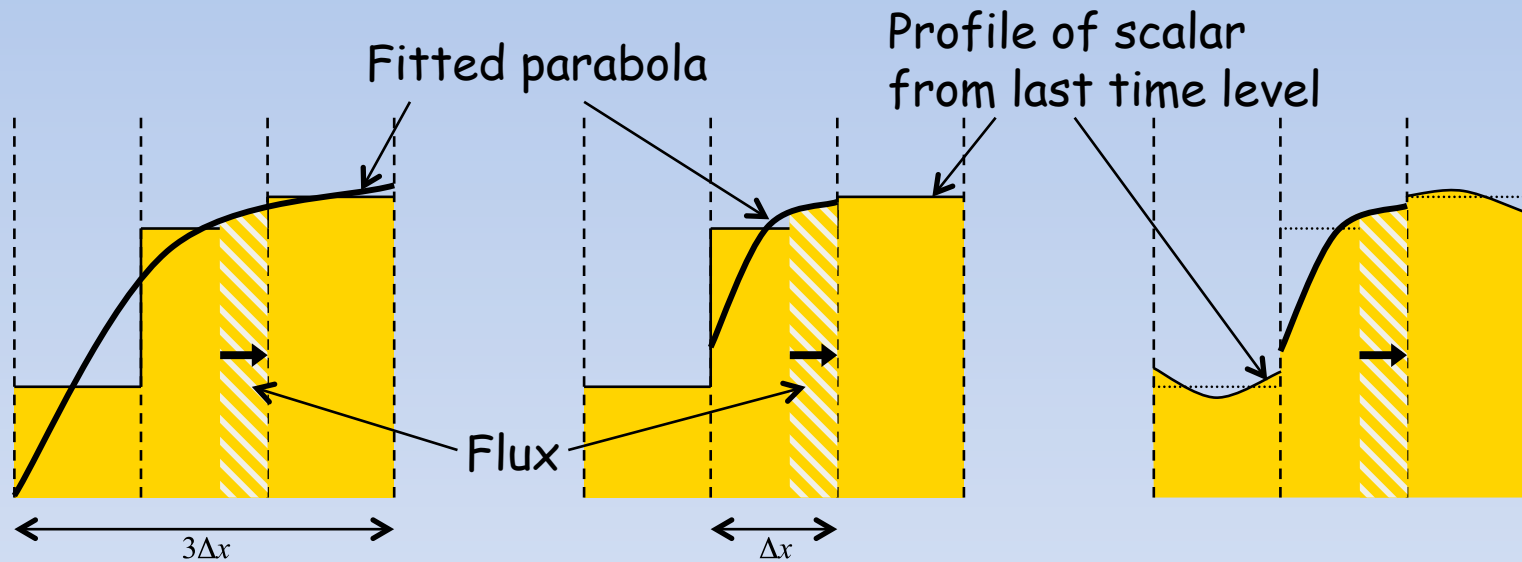


From ECCO2 meeting at JPL, Jan 2007

- Advection: OSn schemes (one step FV schemes)
 - OS7 (seventh order)
 - MP (monotonicity preserving) less diffusive than TVD
 - OS7MP better than limited Prather (SOM)
 - Advocated OSn FV approach over PPM FV approach
 - Since then have developed PQM (White & Adcroft, JCP 2008)
 - Inspired by OS5/7 performance w.r.t. OS3
- Analytic Finite Volume Pressure Gradient Force
 - Solved out-standing PGF issue with partial step topography
 - Paramount for layered models (Adcroft et al., OM 2008)
 - Paramount for general coordinates but needs revision
- Now concentrating on vertical representation

Advection: Variance in concepts



DST3/OS3

- Fits parabola to means of all *three* cells
- $O(\Delta x^3, \Delta t^3)$ accurate

Direct Space Time

PPM

- Fits parabola to mean of local cell + *cubic* interpolation of edge values
- $O(\Delta x^{3+}, \Delta t^{3?})$
- $\sim 3^3$ smaller truncation

Piecewise Parabolic Method

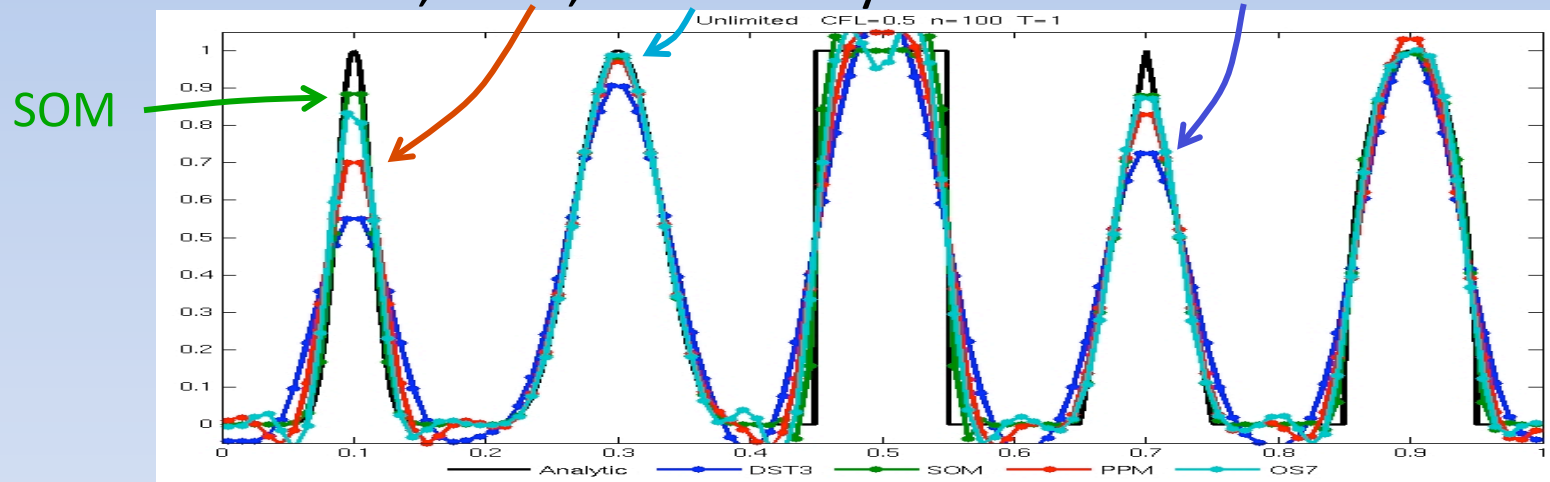
SOM

- Retains parabola from *previous time level* i.e. no fitting!
- Flux of mean, slope and variance
- $O(\Delta x^?, \Delta t^?)$

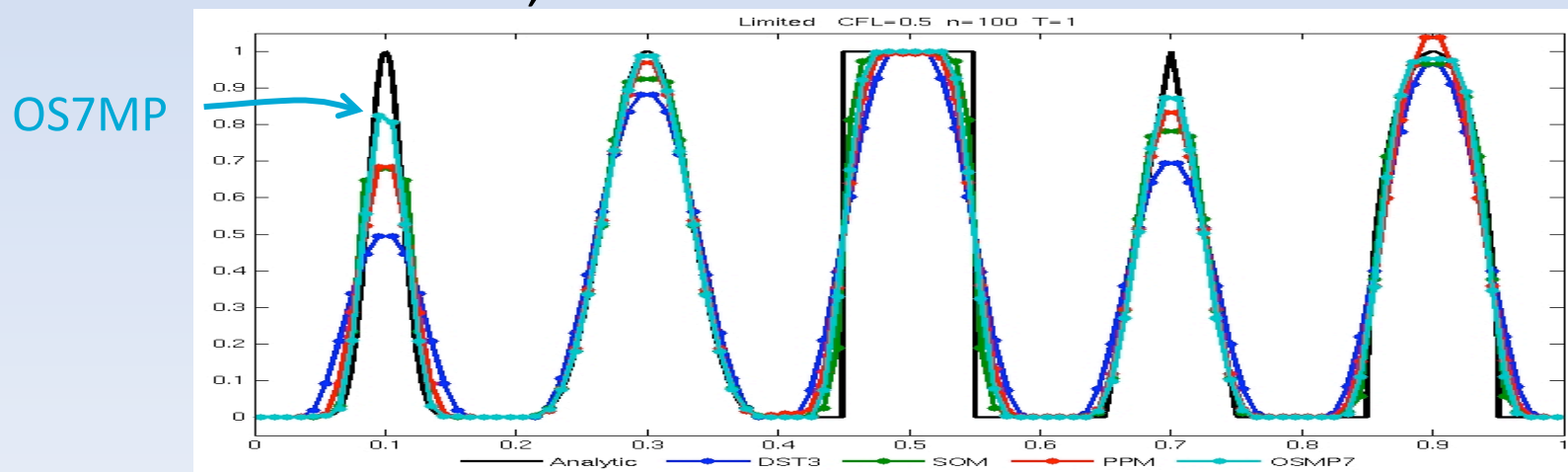
Second-Order Moments
Prather, 1986

Evaluation in 1D

- Umlimited, **PPM**, **OS7** clearly beat **DST3** but **SOM** wins



- When limited, **OS7MP** beats **PPM** and **SOM**



Hybrid coordinates & Kernels

Common formulation

- Level models (z-coordinate)
 - Eulerian algorithm
 - FV approach in 3D
 - Continuous interpretation of structure
- Layered models
 - Lagrangian algorithm
 - FV approach in horizontal
 - Vertical is contained in formulation
 - Piecewise constant interpretation of variables
- General coordinate approach?
- Post-doc: Laurent White

Common software

- Same numerical schemes in many models
 - Duplicity of effort/software
- Different staggering of variables
 - B-grid, C-grid, ...
- Different choice of indexing
 - NE [$u(i,j)$ is to right of $T(i,j)$]
 - SW [$u(i,j)$ is to left of $T(i,j)$]
- Shared software?
- Programmer: Niki Zadeh

Re-gridding & re-mapping

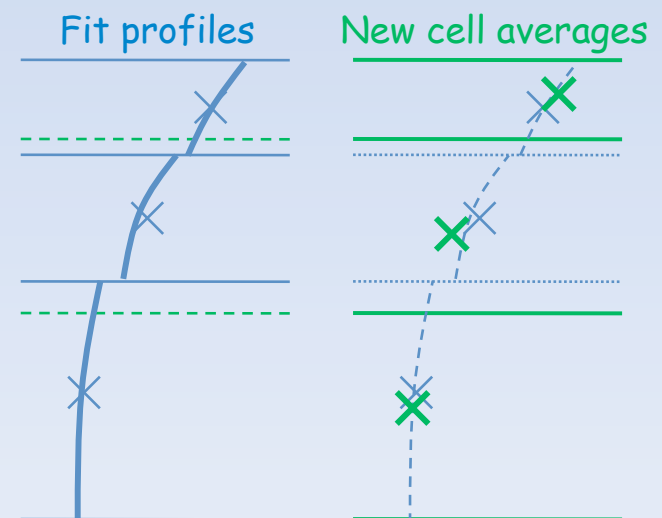
- Re-gridding

- Re-construct global profile
 - Continuous
 - Monotonic
 - (not conservative)
- Find position of new grid



- Re-mapping

- Re-construct local profiles
 - Discontinuous
 - Limited (monotonic)
 - Conservative
- Integrate to find new cell averages

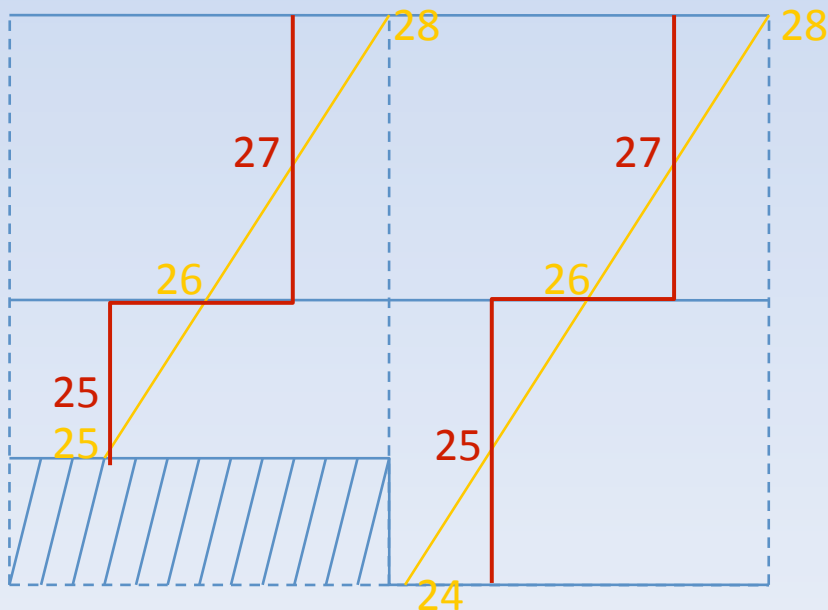


Uncovering inconsistencies

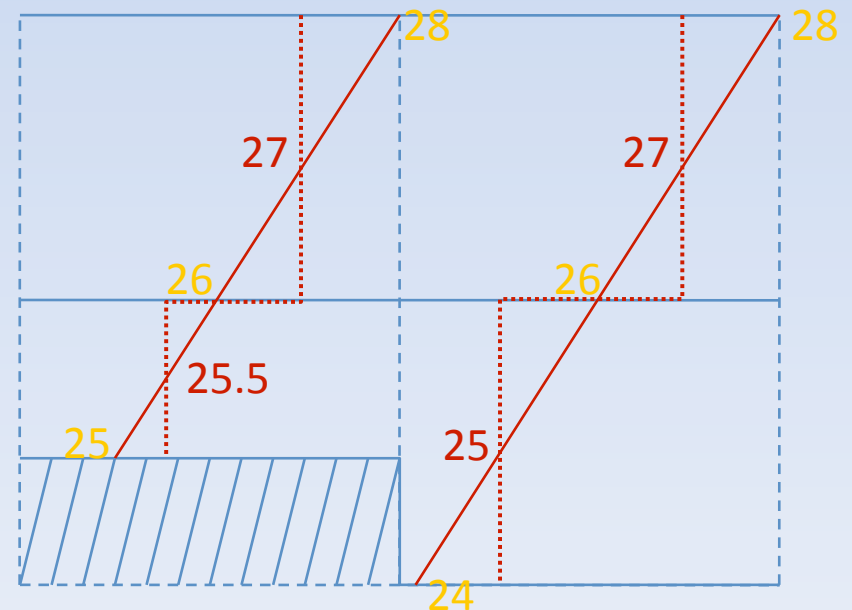
- Choices made on fundamental issues in one part of model have ramifications for rest of model
 - e.g. C-grid Coriolis discretization dictates form of KE which impacts pressure gradient discretization
- Hard to reconcile definition of variables
 - Level models use cell average to represent continuous structure
 - Layer models require piecewise constant and solve physically discontinuous structure
 - These fundamental choices make a lot of difference
- MIT numerics/formulation for z-coords
 - We got it right (mostly)
 - Are self-consistent (mostly)
 - *But do need to re-interpret variables to generalize the vertical coordinate*
 - i.e. re-write some terms
 - So far, changes have always been beneficial
 - Cleans up loose ends
- Need consistent profiles between each of
 - Initialization, pressure calculation, re-gridding, re-mapping
 - Not horizontal transport (continuity) - we think (*phew!*)

Interpreting model variables: initialization

- MITgcm partial steps + layered models
 - Need same density in adjacent cells for no motion



- FV reconstruction
 - Assign “true” average
 - Can reconstruct “real” profile
 - AFV has no pressure gradient error



Kernels

- Reps for MITgcm, HyCOM, POP, ROMS, MOM, GOLD
- Library of routines
 - Proto-typing with horizontal advective flux
 - Extend with vertical advection and re-gridding/re-mapping next
- Fine grained
 - Initially
- Use “soft” conventions
 - Enables NE <-> SW translation
- Dope vectors
 - Works for multiple memory layouts (for different models)
- BLAS- or NAG-like
- Unit tests
 - Validates solutions
 - Tests features
- **code.google.com**
 - search for home-kernel
- Open source
- Open for debate
- Open for contribution (will be)
- But for now, very much under our control! 😊
- Proof of concept
 - Really want to extend to parameterizations

Open issues:

- i,j,k alternatives
- Language (!)
- Adjoint? (loop bounds)
- Performance
- Quite a few others